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**CONCEPTS AND HISTORY**

**A TIME-TESTED METHOD OF PROVIDING EXCEPTIONAL OCCUPANT COMFORT**

**BASIC CONCEPT OF RADIANT ENERGY**

Radiant energy travels through the air reaching objects, is absorbed and is then converted into heat. This is not unlike the sun that sends out radiant energy in straight lines until it reaches a solid object where it is absorbed and warms that object.

All surfaces in a room receive and reradiate energy so that the floor is kept as warm as other surfaces. Panels installed in the perimeter of the ceiling provide a warm, draft-free environment. Radiant heat, unlike convection heat, does not rise.

**THE BEGINNINGS OF RADIANT HEAT**

Radiant heat got its start at the time of the Romans. Many of their buildings employed the use of underground tunnels where hot gases from fires were redirected into hollow masonry walls. Occupants were then warmed by radiant heat from the walls.

Koreans similarly used tunnels to heat their floors which in turn radiated warmth to the occupants. In the 1800s, Europeans followed suit by employing hot water pipes in floors and ceilings to heat their castles and palaces.

Theses designs were comfortable, but not efficient due to poor conduction of both walls and floors. In the last century both hot water piping and electric cables were imbedded in floors and ceilings to radiantly heat homes and buildings. The comfort levels were excellent but the control of these systems was difficult due to the large thermal mass of the ceilings and floors having slow response times.

**RADIANT ENERGY COMES TO AMERICA**

In 1950, Airtite Contractors supplied and installed the first commercial aluminum radiant heating and cooling ceiling in the United States. This lightweight aluminum system had greater heat conduction to the panel surface with increased radiant output than previous systems. The lighter panels provided quicker response to the temperature changes thus overcoming the slower response of older systems.

In the 1960s, technology was developed to metallurgically bond copper tubing to the aluminum ceiling panels. This method is still employed today and provides acoustical control in addition to providing higher radiant output.

In the early 1970s, extruded radiant ceiling panels were developed. Copper tubes were mechanically inserted into the extrusion's heat transfer saddle. This new panel design increased panel output as well as lowering manufacturing and installation costs.

In 2014, Airtite by Steel Ceilings introduced the next line of radiant heating with the AR-L and AR-C product lines which incorporates convection heating with radiant heating. We have continued to provide new innovative designs including our integral linear air bar diffuser extruded panel which provides excellent air-side performance with increased output.
THEORY AND FUNDAMENTALS

There are three basic types of heat transfer: conduction, convection and radiation.

Radiant energy is the transmission of electromagnetic waves that travel in straight lines and are absorbed, heating objects that they strike. These objects reradiate to other colder surfaces.

The best example of radiant heat is provided by the sun. On a cold but sunny day, a person standing outside will absorb the sun’s radiant energy and will feel the warmth. However, the moment a cloud blocks the sun’s radiation and the body can no longer absorb the sun’s heat, that person will immediately feel cool, even though the air temperature has not varied.

The ability of a surface to emit radiant energy is known as emissivity. It is expressed as a decimal ratio of its ability to radiate and is compared to that of a “blackbody”. Blackbody radiation has an emissivity of 1.00. Practically, a surface that emits well will absorb well. Unpainted aluminum has a low emissivity ratio but painted aluminum surfaces will have an emissivity ratio from .91 to .96, depending on the type of paint. Therefore radiant panels that are made of extruded or formed aluminum must be painted to provide good radiant performance.

Radiant ceiling panels have surface temperatures that transmit radiant energy in the infrared portion of the spectrum to which glass is opaque. Radiant energy travels in straight lines heating solid objects such as walls, floors, furniture, people, etc. In turn, all these surfaces in the space reradiate to one another until equilibrium is attained.

ASHRAE defines comfort as “that condition of mind which expresses satisfaction with the thermal environment.” The areas of a heating system that can affect human comfort are room air temperature, air velocities, humidity and mean radiant temperature (MRT) of surroundings. Over the years, studies have been done indicating that MRT strongly influences the feeling of comfort. Perimeter walls with significant amounts of glass will have much lower surface temperatures than the air temperature of the space.

Forced convective air reheat systems are not able to effectively counteract discomfort due to large radiant losses of occupants to the outside wall.

Room air temperatures and humidity are designed and maintained by the air system, but perimeter surface temperatures of walls and especially glass are usually not part of any design. Low surface temperatures of outside perimeter wall/glass can cause discomfort due to occupant radiant losses to these surfaces and downdrafts.

Floor temperatures will be kept equal-to or greater-than the ambient air temperature. Bringing these surface temperatures (MRT) to higher levels by perimeter radiant systems offset human radiant losses and downdrafts.

Ceiling radiant panels have an excellent view of the outside wall, floor, nearby furniture and occupants. This form of asymmetric radiant energy transfer provides optimal comfort. The performance of the radiant panels is directly related to the structure in which it’s located. Exhaustive testing of ceiling mounted radiant panels has been well-established for rectangular rooms where the primary heat losses are from outside walls.

ASHRAE studies indicate radiant systems can achieve excellent occupant comfort with room temperatures at a minimum of three to four degrees lower than normal set points for convective air heating systems. It should be noted that overly conservative design calculations increase panel square footage and should not be used because panel effectiveness and efficiency is reduced and material costs are increased.

In conclusion, the principal benefits of radiant heating in the ceiling are:

- Mean radiant temperature is achieved since all solid objects absorb radiant energy and re-release the energy until equilibrium is reached
- Downdrafts from cold outside walls are reduced
- The side of the human body adjacent to the outside wall receives direct radiant energy, offsetting heat loss to that surface
BENEFITS OF HYDRONIC RADIANT HEATING AND COOLING PANELS

OPERATING COSTS
Hydronic systems generally require 20% of the energy used by all air systems. Since there are no moving parts in the radiant system, maintenance costs are minimal.

SUPERIOR COMFORT
Because surfaces are uniformly heated or cooled, occupant comfort is achieved at lower winter design temperatures and higher summer design temperatures.

ENERGY CONSUMPTION
Energy consumption is reduced by using hydronic heating/cooling and design temperatures as described above.

AESTHETICS
Panels provide excellent architectural appearance with a large array of existing and new design creations.

FLEXIBILITY
Hydronic radiant panels can be incorporated in various ceiling types: lay-in, drywall, soffits, and with no ceilings, providing unrestricted floor space.

DURABILITY
Ceiling panels minimize the possibility of being scratched, bumped or dented.

CONTROL RESPONSE
Efficient, lightweight radiant panels will heat up and cool down quickly.

INDOOR AIR QUALITY
High-quality air filtration can be achieved due to reduced make-up air quantities (100% outside air) needed for ventilation and dehumidification.

DISEASE CONTROL
In radiant cooling, wet coils that provide breeding areas for bacteria and viruses are eliminated. “Once-through” air systems eliminate cross contamination of infectious/airborne diseases.

SPACE REQUIREMENT
For cooling, slab-to-slab height can be reduced, resulting in smaller ducts, reduced plenum heights, and lower air flows. Mechanical equipment rooms are smaller and the radiant system is located in the ceiling giving full utilization of floor space.

CONSTRUCTION SAVINGS
Mechanical construction costs are reduced by utilizing smaller air handlers, smaller duct sizes, and elimination of VAV systems. In addition, reduced slab-to-slab heights are realized.

LIFE CYCLE COSTS
Radiant systems previously evaluated against other typical HVAC systems have shown to have a life cycle cost advantage.

NOISE CONTROL
Perforated panels with insulation can provide noise reduction levels that are lower than standard acoustical ceilings.

GREEN BUILDING DESIGN
A combined radiant panel cooling system designed with a dedicated outdoor air mechanical system offers the potential to earn LEED certification points.
RADIATION EXCHANGE FORMULA

A GRAPHIC DEPICTION AND ENGINEERING FORMULA FOR RADIANT HEATING ENERGY

The basic equation for radiation exchange is the Stefan-Boltzmann equation. This equation may also be expressed as:

\[
Q_r = 0.1713 F_a F_e \left[ \left( \frac{T_r}{100} \right)^4 - \left( \frac{T_p}{100} \right)^4 \right]
\]

- \(Q_r\) = Heat transferred by radiation, BTU per (hour) (sq. ft.)
- \(T_r\) = Mean radiant temperature of unheated surface, Fahrenheit, absolute
- \(T_p\) = Average surface temperature of heated panel, Fahrenheit, absolute
- \(F_a\) = The configuration factor (dimensionless).
- \(F_e\) = The emissivity factor (dimensionless).
- 0.1713 = Stefan-Boltzmann radiation constant, BTU per (hour) (sq. ft.)

[Rankin (absolute Fahrenheit) temperature to the fourth power]
DESIGN PROCEDURE FOR COOLING/HEATING

The design of a radiant cooling/heating system should follow the usual guidelines of an air-water system. To create such a system, we need to find the following:

1. Establish inside room design dry bulb temperature, relative humidity, and dew point
2. Calculate the room’s internal loads (sensible and latent)
3. Calculate air side room requirements
4. Select mean water temperature
5. Determine panel area required
6. Check panel capacity for heating
7. Determine flow and pressure drop

DESIGN EXAMPLE:
Single Patient Hospital Room
Outside design conditions:
Summer: 95°F Dry Bulb, 78°F Wet Bulb
Winter: -10°F Dry Bulb

1. Establish inside room design conditions and parameters
   Room dimensions: 12’ x 12’ (144sf)
   Glass: 25% of outside wall
   Toilet dimensions: 6’ x 8’ x 8’
   Inside design conditions:
   76°F Dry Bulb
   Relative humidity: 45%
   Dew point: 53°F
   Absolute humidity: 60 GR/LB of dry air
   Primary chilled water temp: 42°F

2. Internal Loads
   Sensible Load:
   Summer: 5200 BTUH gain
   Winter: 6800 BTUH loss
   Latent Load: 580 BTUH gain (people infiltration)

3. Calculate air side room requirements
   Air quantity must meet minimum code/design requirements. The air must handle the latent load and CFM/SF must be adequate for comfort and odor removal.

Code Requirement
Code requires 4 AC (air changes)/HR of outside air be supplied to the room and 10 AC/HR be exhausted from the toilets.

Supply CFM
\[ \frac{144 \text{ SF} \times 9 \text{ ft. Ceiling} \times 4 \text{AC}}{60 \text{ min/hr}} = 86.4 \text{ CFM} \]

Toilet exhaust
\[ \frac{6’ \times 8’ \times 8’ \times 10 \text{ AC}}{60 \text{ min/hr}} = 64 \text{ CFM} \]

Soiled Linen Cabinet Exhaust
15 CFM  Total Exhaust = 79 CFM

For good air motion, use 0.6 CFM.
144 SF x .6 CFM/SF = 86.4 CFM
Code and comfort calculations indicate 86.4 CFM.
Design at 90 CFM

Calculate Latent Capacity
The internal moisture pickup with 90 CFM

\[ \text{IMP} = \text{Internal latent load} \times \frac{0.68}{\text{CFM conditioned}} \]

\[ \text{IMP} = \frac{580 \text{ BTUH}}{90 \text{ CFM} \times 0.68} = 9.5 \text{ GR/LB} \]

Use 10 GR/LB (grains of water/pound)
Determine the required delivered air conditioning to offset this 10 GR/LB pickup.
Grains maintained – Grains pick up = Grains to be delivered
60 GR/LB – 10 GR/LB = 50 GR/LB
maximum in delivered air.

Referring to a psychometric chart, air entering the air handling unit in the summer at 95°F DB, 78°F WB, has .118 GR/LB. Air leaving the unit has been cooled and dehumidified, leaving the coil at 52°F DB and 50°F WB having 50 GR/LB, allowing for ample latent load pickup. Air will be delivered to the room at 54-55°F.

Continued
4. Select the mean water temperature
The secondary supplied chilled water temperature to the ceiling should be a minimum of 1° above the design dew point of the room panels:
Room dew point of 53°F + 1°F = 54°F

Supply Water Temp
Normally a 4-6°F water temperature rise (WTR) is used. For this example use a 5°F WTR.

\[ \text{MWT} = \text{Supply Water Temp} + 0.5 \times \text{design WTR} \]
\[ \text{MWT} = 55°F + 2.5°F = 57.5°F \text{ MWT} \]

5. Determine the panel area required
Refer to the Cooling Performance Table.
Room Air Temperature – MWT
76°F Dry Bulb – 57.5°F = 18.5°F difference

At 25% glass from the performance chart with an 18.5 difference panel capacity for above conditions = 44 BTUH/SF (sensible cooling)

Cooling
Required panel cooling =
Total Sensible Cooling – Air Sensible Cooling

Sensible Cooling w/Air = Conditioned CFM x 1.08°F x (Room Air °F – Supply Air °F)

\[ 1.08 = 60 \times 0.24 \]
\[ 13.34 = \text{CUFT/LB of standard air} \]
\[ 60 = \text{MIN/HR} \]
\[ 0.24 = \text{Specific heat of air} \]

90 CFM x 1.08 x (76 – 55) = 2041 BTUH

Required cooling =
5200 BTUH – 2041 BTUH = 3159 BTUH

Panel area required =
\[ \frac{3159 \text{ BTUH}}{44 \text{ BTUH/SF}} = 71.8 \text{ SF} \]

6. Check panel capacity for heating
The radiant panel must pick up the winter design load plus the air side reheat.

Air side reheat = 90 CFM x 1.08 x (76-55) = 2041 BTUH
Total load = 6800 BTUH + 2041 BTUH = 8841 BTUH

According to perimeter and interior performance tables, a 150°F MWT is adequate for heating.

7. Determine the water flow (GPM) and pressure drop (ft of water)
Refer to Pressure Drop Table for design data on pressure drops for heating and cooling.

\[ \text{GPM} = \frac{\text{Total BTUH for panels}}{500 \times \text{Water Temperature Difference}} \]

Cooling GPM = \[
\frac{3159 \text{ BTUH}}{500 \times 5°F} = 1.26 \text{ GPM} \]
Use 1.3 GPM

Heating GPM = \[
\frac{8841 \text{ BTUH}}{500 \times 20°F} = .89 \text{ GPM} \]
Use 1.0 GPM

8. Pressure loss for copper tubing
Select the proper table for the type of pipe. Type K copper pipe has the thickest wall and highest pressure ratings of the common copper tubing types. In order of wall thickness, common copper tubing types are Type M (thinnest), Type L, and Type K (thickest).

Type L is commonly used for household plumbing. If you don’t know what Type the pipe is, assume it is Type K. Locate the proper column on the table for the pipe size.

Read down the column to the row for the flow rate (GPM) in the pipe section. You will find a PSI loss value (given as PSI/100).

Multiply the PSI loss value shown by the total length of the pipe section, then divide the product by 100. (PSI loss on these tables is given in PSI per 100 feet of pipe.)

Value * Length / 100 = PSI loss

See next pages for pressure loss in copper tubing and pressure loss in metric tubing (table from MAPRESS).
PRESSURE LOSS OF WATER DUE TO FRICTION IN TYPES K, L AND M COPPER TUBE
(PSI PER LINEAR FOOT OF TUBE)

<table>
<thead>
<tr>
<th>GPM</th>
<th>3/8&quot; K</th>
<th>3/8&quot; L</th>
<th>3/8&quot; M</th>
<th>1/2&quot; K</th>
<th>1/2&quot; L</th>
<th>1/2&quot; M</th>
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</thead>
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<td>1</td>
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<td>0.023</td>
<td>0.021</td>
<td>0.01</td>
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<td>0.007</td>
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<td>0.086</td>
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</tr>
<tr>
<td>5</td>
<td>0.195</td>
<td>0.161</td>
<td>0.13</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTES
1. Fluid velocities in excess of 5-8 feet per second are not recommended
2. Friction loss values shown are for the flow rates that do not exceed a velocity of 8 feet per second
3. Table based on the Hazen-Williams formula below:
   \[ P = \frac{452Q^{1.85}}{C^{1.85}}d^{4.87} \]

Where:
- \( P \) = friction loss, psi per linear foot
- \( Q \) = flow, g.p.m.
- \( d \) = average I.D. in inches
- \( C \) = constant, 150
Pipe pressure gradient due to friction $R$ and calculated flow velocity $v$ as a function of peak flow rate $V_p$ at $T = 10^\circ$C

Copper pipes to DVGW Code of Practice GW 392/DIN EN 1057

$k = 0.0015$ mm

<table>
<thead>
<tr>
<th>PEAK FLOW RATE $V_p$ (liters/sec.)</th>
<th>PIPE OUTSIDE DIAMETER X WALL THICKNESS $15 \times 1.0$, $13 \times 1.0$, $12 \times 1.0$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0.05$</td>
<td>$2.2$, $0.38$</td>
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<td>$0.06$</td>
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<td>$0.07$</td>
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<td>$0.08$</td>
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<td>$0.09$</td>
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<td>$0.10$</td>
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<td>$0.65$</td>
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</tr>
<tr>
<td>$0.70$</td>
<td>$225.5$, $5.3$</td>
</tr>
</tbody>
</table>
Panel Control Considerations

Radiant systems can be controlled the same as any perimeter hot water heating system. Radiant panels operate best with indoor/outdoor water supply temperature reset. This allows the radiant output to most closely match the perimeter load at design flow. When modulating control valves are used with a 20°F delta temperature, a 50% reduction in flow reduces the M.W.T. by 10°F with a corresponding 10% reduction in panel output.

Many systems supplied and installed by Airtite have successfully operated with constant water flow and variable water temperature as shown in 1. In this arrangement the VAV box operating with supply economizer air modulates to meet the thermostat set point. The addition of a hydronic modulating valve as shown in 2 adds further control.

Schemes 3 & 4 utilize hydronic reheat coils in the VAV boxes. The control sequence must be that the radiant panels heat first and if additional heat is required then airside reheat is provided. If room temperatures rise above the thermostat set point, the flow to the airside hydronic reheat coil would first modulate down and lastly the water flow to the radiant panels. In all cases the radiant panel must be the first on providing heat and the last off.

Solenoid valves (on/off) are not recommended because they cycle, not allowing continuous radiant energy transfer to the walls, floors, furniture, and occupants for the best level of comfort.

Note: Only water-side control shown. VAV BOX airside control not shown.

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Solenoid valves (on/off) are not recommended because they cycle, not allowing continuous radiant energy transfer to the walls, floors, furniture, and occupants for the best level of comfort.

Note: Only water-side control shown. VAV BOX airside control not shown.
The AR-X hydronic extruded aluminum radiant panel is a well tested, proven design. The panel has a very attractive fluted face and a highly efficient heat transfer saddle on the back of the panel.

Copper tubes are mechanically reformed within the saddle providing superior tube contact. The panel efficiency is over 90% of a full-flooded hollow panel of the same width. Panels with larger tube diameters have been comparatively tested against this design and have shown no increase in performance. Panel widths from 8 to 24 inches in standard ceiling heights have provided excellent human comfort long associated with radiant systems.

A perimeter hot water radiant ceiling eliminates downdrafts and increases exterior wall surface temperatures providing a very comfortable thermal environment especially with perimeter walls having large glazed areas.

The unique, attractive design becomes an aesthetic enhancement to the overall architectural interior design while providing increased space utilization, flexibility, and lower first-installed costs. The elimination of perimeter baseboard with expensive architectural covers and other floor-mounted heating systems provide flexibility in design, full utilization of floor space and unrestricted furniture location.

The AR-X Airtite radiant extruded aluminum panel can easily be integrated in lay-in ceilings, drywall ceilings, soffit rises or drops—and no ceilings at all. This system lends itself to either new construction or retrofits.

Retrofits can be accomplished without shutting down multiple floors or large areas of the building that would cause loss of revenue due to interruption of occupancy.

AR-X Airtite extruded radiant panels have a higher STC rating than most acoustical ceilings minimizing sound transmission.

As with any hydronic system, fuel savings are realized through the highly efficient use of energy. Rising energy costs make this system very competitive in fuel savings, especially because comfort levels are excellent at air temperatures 3-4° lower (thermostat set point) than conventional systems. The panels themselves are maintenance-free and lend themselves to lower life-cycle costs.

Perimeter radiant systems have been effectively used for over 50 years and have become a system of choice by both architects and engineers.
**STANDARD AR-X EXTRUDED SECTIONS**

6" SINGLE PASS
6" SINGLE PASS
12" TWO TUBE RADIANT PANEL

6" SINGLE PASS
6" SINGLE PASS
6" SINGLE PASS
18" THREE TUBE RADIANT PANEL

6" SINGLE PASS
6" DOUBLE PASS
6" SINGLE PASS
18" FOUR TUBE RADIANT PANEL

6" SINGLE PASS
6" SINGLE PASS
6" SINGLE PASS
6" SINGLE PASS
24" FOUR TUBE RADIANT PANEL

6" SINGLE PASS
6" SINGLE PASS
6" SINGLE PASS
6" SINGLE PASS
6" SINGLE PASS
30" FIVE TUBE RADIANT PANEL

6" SINGLE PASS
6" SINGLE PASS
6" SINGLE PASS
6" SINGLE PASS
6" SINGLE PASS
36" SIX TUBE RADIANT PANEL

**ASSEMBLED RADIANT PANEL SECTIONS**

**Ceiling Opening Schedule**
The radiant panels shown on drawings are stock lengths and are to be field-cut to fit the job site conditions. These conditions include miters, notches, etc. Consult the chart below for ceiling width opening requirements.

<table>
<thead>
<tr>
<th>NOMINAL PANEL WIDTH</th>
<th>CEILING OPENING WIDTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>12&quot;</td>
<td>12 1/4&quot;</td>
</tr>
<tr>
<td>18&quot;</td>
<td>18 3/16&quot;</td>
</tr>
<tr>
<td>24&quot;</td>
<td>24 1/8&quot;</td>
</tr>
<tr>
<td>30&quot;</td>
<td>30&quot;</td>
</tr>
<tr>
<td>36&quot;</td>
<td>36&quot;</td>
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</table>
EXPLLODED PANEL ASSEMBLY

CENTER CLIPS

EDGE CLIP

CROSS-CHANNEL

EDGE CLIP

ASSEMBLED PANEL
AR-X COOLING PERFORMANCE:

Cooling Performance for Extruded Panels

<table>
<thead>
<tr>
<th>Room conditions and percent glass</th>
<th>NO GLASS IN</th>
<th>25% CLEAR</th>
<th>50% CLEAR</th>
<th>75% CLEAR</th>
<th>100% CLEAR</th>
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<tr>
<td>INTERIOR</td>
<td></td>
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<tr>
<td>SUN OR FULLY SHAPED GLASS AND WALL IN</td>
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<tr>
<td>10</td>
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AR-X ENERGY EFFICIENCY
PERIMETER HEATING OUTPUT (BTUH/LF)

Total certified output shown is per lineal foot of panel at the perimeter of the space. Output is based on 70°F air temperature; 67°F average unheated surface temperature (A.U.S.T.), with one inch of 3/4” PCF unfaced fiberglass batt insulation on top of the panel, and natural convection. Actual output with minimum ventilation significantly increases panel output (approximately 10-15%).

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INTERIOR HEATING (BTUH/SF)

AR-X ENERGY EFFICIENCY
TYPICAL AR-X PANEL DESIGN
CONNECTION DETAILS

Standard panel tubing size is 0.544" OD - 0.504" ID ALLOY 122 COPPER and is rated at 400 P.S.I.G.

A Connection to Airtite panel tubing

B Airtite return U-bend

C Airtite 360° interconnect

For odd number tubing passes, hook-up supply and return at opposite ends.
AR-X EXTRUDED PANEL PIPING

Odd number tubing passes; opposite end connections
- Soldered connections. No fitting required.
- For odd number tubing passes, hook-up supply and return at opposite ends
- Maximum single-panel length = 16’
- Refer to architectural details for typical sections

Even number tubing passes; same end connections
- 1/2” O.D. soft copper tubing (typical)
- Airtite 360° interconnect
- Parallel flow in even pass Airtite panels reduces pressure drop for long zones
- Maximum single-panel length = 16’
- Refer to architectural details for typical sections

Steel Ceilings Inc.
Manufacturer of Metal Ceilings and Specialty Systems
AR-X DESIGN PROCEDURE AND EXAMPLES

DESIGN PROCEDURE
The design of a radiant ceiling panel heating system should follow the usual guidelines of a closed water system. To design such a system, we need to find the following:
1. Calculate the heat loss per zone or room
2. Determine the panel width
3. Determine the panel layout and water flow
4. Calculate the water pressure drop based upon piping arrangement

DESIGN EXAMPLE: RECTANGULAR BUILDING
Given conditions:
• 100 ft. rectangular building
• 12 ft. floor-to-floor
• Inside design = 72°F Dry Bulb
• Supply Water Temp = 200°F
• Return Water Temp = 180°F
• Heat Loss for each floor = 170,000 BTUH
• Assume a 60 L.F. zone

Design A
1. Calculate the perimeter heat loss per lineal ft. and heat loss per zone
   \[
   \text{Total Load} = \frac{170,000 \text{ BTUH}}{500 \text{ L.F.}} = 340 \text{ BTUH/L.F.}
   \]
   For 60 L.F. zone = \[ \frac{340 \text{ BTUH/L.F.} \times 60 \text{L.F.}}{500 \times 20^\circ°F} \]
   \[ \approx 2.04 \text{ GPM} \]

2. Determine Panel Width
   From the performance tables, a 16”-wide 4-tube panel at 190°F MWT has an output of 343 BTUH/L.F.

3. Determine panel layout and water flow
   Based on either room size or zone length, panel lengths range from 8 L.F. to 16 L.F. Therefore, a 60-ft. zone (circuit) without perimeter walls would have five @ 12 L.F. panels.

   \[ \text{GPM} = \frac{\text{Total BTUH/zone}}{500 \times \text{water temp. drop}^\circ°F} \]
   \[ = \frac{60 \text{ L.F.} \times 340 \text{ BTUH/LF}}{500 \times 20^\circ°F} \]
   \[ = 2.04 \text{ GPM} \]

4. Calculate the water pressure drop based upon piping arrangement
   For this example, a 16”-wide 4-tube panel would have two parallel circuits at 1.02 GPM/each. Calculate the total lineal foot of panel tubing.
   \[ \text{L.F. of tubing} = 2\text{crts} \times 5\text{pns} \times 12 \text{L.F.}/\text{section length} = 120 \text{L.F. of panel tube} \]
   \[ \text{Interconnects/crt} = 2 \times 4 = 8 \]
   Each interconnect is equal to 1.5 L.F. of tube. Therefore 8 interconnects = 12 L.F.
   \[ \text{Total} = 120 \text{L.F.} + 12 \text{L.F.} = 132 \text{L.F. of tube.} \]
   Per the pressure drop table at 1.0 GPM shows 3.26 ft. of W.P.D per 100 ft. of tube. Total pressure drop for this circuit:
   \[ 132 \times 3.26 = 4.30 \text{ ft. of water} \]

Steel Ceilings Inc.
Manufacturer of Metal Ceilings and Specialty Systems
**Design B**

Using the same example, if panels were between columns and there were six columns in the zone at 10’ each, the load per L.F. of panel would increase.

1. **Calculate the perimeter heat loss per lineal ft. and heat loss per zone**
   
   60 L.F. x 340 BTUH/L.F. = 20,400 BTUH
   
   Available panel = 55 L.F.
   
   Heat loss/L.F. of panel = 26,250 BTUH
   
   BTUH/L.F. = 371

2. **Determine Panel Width**
   
   From the performance tables, an 18 in. wide 4-tube panel at 90°F MWT has an output of 378 BTUH/L.F.

3. **Determine panel layout and water flow**
   
   This panel layout is as described below with the same GPM = 1.0 GPM

4. **Calculate the water pressure drop based upon piping arrangement**
   
   L.F. of tubing
   
   = 2 x 11 L.F./panel x 5 panel sections
   
   = 110 L.F.
   
   L.F. of 3/8 in. copper
   
   = 10 L.F./col. x 4 cols.
   
   = 40 L.F.

Per the pressure drop table at 1.0 GPM shows 3.26 ft. of W.P.D per 100 ft. of tube.

Pressure drop for panel tube on this circuit:

\[
110 \times 3.26 = 3.59 \text{ ft. of water}
\]

Per the pressure drop table for 3/8” L copper, at 1.0 GPM shows 7.07 ft. of W.P.D per 100 ft. of tube.

Pressure drop for 3/8 in. copper:

\[
40 \times 7.07 = 2.82 \text{ ft. of water}
\]

Total pressure drop = 3.59 + 2.82

= 6.41 ft. of water
AR-X SAMPLE SPECIFICATION

DIVISION 23- 80 Decentralized HVAC Equipment

PART 1 – GENERAL

1.1 Scope
• Furnish and install Steel Ceilings, Inc. Airtite Radiant Ceiling (AR-X Extruded Radiant Panels)

1.2 Related Sections
• Section 20 07 00 – Mechanical Systems Insulation
• Section 23 05 94 – Water Systems Test Adjust Balance
• Section 23 21 16 – Pipe and Pipe Fittings
• Section 23 21 18 – Valves
• Section 23 01 00 – Operation and Maintenance of HVAC Systems
• Section 23 05 00 – Common Work Results for HVAC
• Section 23 09 00 – Instrumentation and Control for HVAC
• Section 23 20 00 – HVAC Piping and Pumps
• Section 23 30 00 – HVAC Air Distribution

1.3 Reference
• Work under this section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions and sections under Division 01 General Requirements
• American Society for Testing and Materials
• C635 Standard specifications for the manufacture, performance and testing of metal suspension systems for acoustical tile and lay-in panel ceilings
• C636 Standard practice for installation of metal ceiling suspension systems for acoustical tile and lay-in panels
• E84 Test method for surface burning characteristics of building materials
• CISCA Ceilings and Interior Systems Construction Association

1.4 Submittals
• Provide product data sheets listing dimensions, style, edge detail, perforation pattern, finish and thermal performance
• Alternates require prior approval no later than 21 days prior to bid date. In addition to the requirements above, submittals for approved alternates must include samples of actual products to be substituted together with test certificates supporting performance claims, a mock up and a written warranty.

1.5 Project Conditions
• Area to receive ceiling systems shall be protected from the direct weather
• Wet trades work shall be complete and dry prior to installation of ceiling system

1.6 Attic Stock
• Provide 2% of the ceiling system area materials to be used as attic stock

1.7 Performance
• Materials and installation must comply with local building code and regulations
• Material should be stored and handled in accordance with CISCA’s Acoustical Ceilings – Use and Practices
• Material to comply with CISCA’s Metal Ceilings Technical Guidelines
• There are no special seismic requirements

PART 2 – PRODUCTS

2.1 Manufacturer
• Steel Ceilings, Inc. Airtite Radiant panels manufactured in Johnstown, OH: www.steelceilings.com

2.2 Materials
2.2.1 Panels
• AR-X panels shall be constructed of aluminum extrusions providing panel widths from 4” up to 60” wide and up to 16’ long. Painted with polyester powder, Steel Ceilings, Inc. Sandtex, other colors available.

2.2.2 Linear Panels AR-X
• Approved Manufacturers:
  • Steel Ceilings, Inc. of Johnstown, OH; www.steelceilings.com
  • Alternates or approved equals are acceptable if and only if a mock-up and witness test is performed to demonstrate that the substitution meets design criteria

Continued
Sample specification continued

• AR-X linear panels shall be manufactured from extruded aluminum with an integrated heat sink(s) on the back to transfer heat between the copper tube(s) and the panel face
• The radiant linear ceiling panel shall be manufactured of extruded aluminum with flutes. The panel shall consist of interlocking extruded sections with channel cross-braces attached by plated steel clips. Each section shall have at least one integral heat saddle with a copper tube mechanically reformed into the heat saddle such that the tube is in intimate engagement with the heat saddle, which shall extend more than half way around the tube. A non-hardening conductive medium shall be applied between the copper tube and the aluminum extrusion. The use of adhesive, clips, or screws that attach the copper tube to the extrusion will not be acceptable.
• Water tubes shall consist of ASTM B75 ½" nominal copper tubing. Water connections shall be one end only. Water connections shall be suitable for solder, compression fittings, push-on fittings or threaded connections.
• All visible components are powder-coated with a high-emissivity polyester powder for efficient radiative properties. The polyester powder provides a durable and easy to clean surface treatment.
• The standard color provided is Steel Ceilings, Inc. white, other colors are available upon request
• Water connections shall be shipped sealed to limit the introduction of dust and dirt during shipping and construction
• Accessories
  - Braided stainless steel connections hoses (12” & 18”) with oxygen barrier liner can be provided on request
  - Isolation control valves can be provided on request
  - Header assemblies can be provided on request
  - Fiberglass 1” x 1 pcf to be supplied for insulation of the back of the panel

2.2.3 Performance
• Panels shall provide heating and cooling as laid out in the engineer’s requirements

PART 3 – EXECUTION

3.1 Examination
• Installer must inspect the area that is to receive the metal ceiling system for conditions that may affect the installation and notify, in writing, any conditions that must be rectified before commencing
• Installer should inspect all materials delivered to the job site for shipping damage and notify, in writing, Steel Ceilings, Inc. if any damage is found

3.2 Installation
• All material should be stored in a dry and protected area
• All work above the ceiling shall be completed before proceeding with this installation
• All wet work shall be completed and thoroughly dry before proceeding with this installation
• Install the ceiling system in accordance with the manufacturer’s recommendations and the approved shop drawings
• Panels shall be free from defects
• Damaged panels shall be removed and replaced

3.3 Connections
• Piping installation requirements are specified in other Division 23 Sections. General arrangement of piping, fittings, and specialties are indicated on the drawings.
• In order to improve the hydronic performance and efficiency connect the copper tubing to the supply line with shut-off valve, strainer, control valve, and union or flange. Connect the return line with balancing valve and union or flange.

3.4 Field Quality Control
• Perform the following leak tests and inspections and prepare test reports:
  - Leak Test: After installation, fill lines with clean dry air check for air loss and/or leaks. Repair leaks and retest with air until there are no leaks.
  - Leak Test with water: Once the initial leak test has been completed re-test the system with water
  - Operational Test: After electrical circuitry has been energized, start units to conform to proper unit operation
  - Test and adjust controls and safeties: Replace damaged and malfunctioning controls and equipment

3.5 Cleaning and Protection
• Clean all visible surfaces of equipment; touch up as required
• Protect all units before, during and after installation. Damaged panels due to improper protection or mishandling is the responsibility of the installer.
AR-X PANEL ASSEMBLY FOR HYDRONIC RADIANT HEATING/COOLING PANELS

NOTE: Panels are provided 3/8” less than their nominal length (i.e., a nominal 16’ panel is supplied 15’-11 5/8” long) so that cross-tee center spacing will be equal to the nominal panel length).

Additional cross-tees should be installed at a center to center spacing equal to the nominal panel length. These cross-tees should be cut so as to maintain the distance between the wall channel and the main runner. The length of the cross-tee should be slightly less than the wall channel to main runner spacing to allow for expansion. The face of the cross-tee, wall channel and main runner should be flush for a more attractive job.

The last panel installed in a continuous run should be cut to a length of 3/8” less than the space between the end wall and the center line of the final cross-tee. Pop rivets should not be used where they will touch the panel face because the rivets will hold the panel up off the suspension members, causing an unsightly installation.

Miter cuts, cuts around columns and other special cuts should be treated in a manner similar to those described above. Contact your local Airtite/Steel Ceilings, Inc. representative for recommendations.

PANEL ASSEMBLY REQUIREMENTS

The Airtite AR-X extruded panels are part of the finished surface within the occupied space. The face must be protected at all times from damage. White gloves should be worn by all personnel touching the panel to eliminate fingerprint marks. The gloves should be discarded once they become soiled.

All panels should be assembled on a work bench at least as large as the largest panel to be used on the job. This bench is essential for simple and efficient assembly. The bench should be clean and use of a protective material is recommended. The protective material should be of a color to show dirt so it can be changed when soiled. We recommend white paper.

PANEL ASSEMBLY COMPONENTS

- Appropriate panel extrusions
- Cross-channels
- Silver colored end clips
- Yellow colored center Clips
- Claw hammer & Screwdriver
- Tape measure
- Power saw
- Airtite tube lifting/sizing tool

PANEL ASSEMBLY

The panel cross-channel is 1/2” x 3/4” x 1/2”, 16 gauge, galvanized steel. It is commonly referred to as galvanized lathers’ channel. It can be ordered precut to size from Steel Ceilings. The outboard cross channels should be fastened within 2” of the ends of the panels (including mitered cuts). The remaining channels should be equally spaced. Contact your local Airtite/Steel Ceilings, Inc. representative for recommendations.

To assemble a panel, first lay out the required number of extrusions on the workbench. Push the panels together (tongue and groove) and true up the ends (a stop would be useful). Clamps should be used on the flanges between the sections to hold the extrusions together during assembly. Insert a silver-colored clip into each end of a pre-cut cross-channel and fasten to the edge flanges along the length of the panel. The clips can be hammered onto the flanges, taking care not to deform the panel. The yellow-colored clips hold the channel to the intermediate flanges. They should be installed on alternate sides of the cross-channel.

PANEL MODIFICATION

The panel can be modified to suit almost any situation. The panel can be cut anywhere, and the tubing lifted and reconnected. Two common situations are mitering at corners or trimming to fit around a column. Carefully measure the panel prior to cutting, while making sure to allow for expansion of the panel. Miter joints should be checked prior to cutting, as the exact angle at a corner must be determined. Remember—measure twice, cut once.
The face of the panel must be protected during cutting operations. It may be necessary to use a plate to protect the face of the panel from the saw shoe. Any of the following may be used to cut the panel:

1. A metal cutting ban saw with metal cutting blade. Follow saw manufacturer’s recommendations.
2. Circular saw with the carbide-tipped aluminum cutting blade, equal to Oldham saw blade No. 725-C-CBVM
3. Heavy duty jig saw. A Bosch No. 1578 with T277D blade may be used.

The cut ends of the panel should be supported with cross-channel to help maintain panel flatness. The standard clips can be used at the miter joints by gently bending the clips. Cross-channels should be fastened within 2” of the end of the panel.

**CONNECTION OF THE COPPER TUBING**

For interconnecting panel tubing in long runs, Airtite/Steel Ceilings, Inc. offers a 360° expansion loop pre-sized to fit the panel tubing without the need for fittings. Return U-bends sized for 2”, 4”, 5”, or 6” O.C. spacing can also be provided. The 360° expansion loop has been designed for attachment to copper tube on the panel after the tube has been raised with the Airtite tube lifting/sizing tool.

3/8” type “M” or “L” (0.500”O.D.) tubing can be used for supply and return connections, interconnects, U-bends, or to pipe around columns. The ends of the tubing on the back of the panel are sized to accept 0.500” O.D. tubing without the need for fittings. If the pressure drop is excessive when 3/8” “M” or “L” is used, then it is recommended that 360° interconnects, U-bends, and “around column” interconnects be purchased from Airtite/Steel Ceilings, Inc. which are produced from special tubing sized to accept the panel tubing without the need for fittings.

Panels which have been cut will require the remaining copper tubing to be shortened (offset) to allow space to make piping connections.

This simple procedure involves the use of a circular saw and is described below.

1. Mark the tube offset (normally 4 5/16” from the end of the panel)
2. Adjust the shoe of the saw to depth so it will just cut the tubing from the back of the panel without cutting through to the face of the panel
3. Cut the tubing by lowering the blade onto the tube. Hold panel down when lifting up to remove scrap tube to prevent aluminum extrusion from taking a non-flat set.
4. Use a screwdriver or similar tool to remove the scrap tube from the saddle. Hold panel down when lifting up to remove scrap tube to prevent aluminum extrusion from taking a non-flat set.
5. Clean the white paste out of the tube saddle. A solvent such as trichloroethylene will remove the paste. Be sure to follow label directions when using these solvents.
6. Insert the male mandrel of the tube lifting/sizing tool into the copper tube. Tap care that the mandrel is fully inserted into the tube, as partial insertion may damage the tubing.
7. Push down on the raised end of the tool while holding the tool tight to the back of the panel until the sizing socket strikes the back of the tubing. The end is now bent up at the proper angle for the attachment of the 360 degree interconnects or U-bends.
When soldering the connection use specified materials making sure that each joint is well capped. Good piping practice should be followed. Take care to keep the flame from the torch away from the panel surface. Wipe the joints of excess flux after soldering and pressure-test per specs (silver solder or brazing of the joints may be specified).

**INSULATION**

An insulation blanket, if specified (usually 1” thick, 1-lb. density), should cover the entire back of the radiant panel. Cut the blanket to pass around the suspension wires and interconnecting piping. Make sure that the blanket abuts the adjacent blanket tightly. Do not place the insulation blanket over any incandescent or florescent light fixtures.

Interconnecting piping is not insulated unless specifically required by the specs. Airtite does not recommend insulating interconnecting piping.

**START-UP**

Each zone of panels should be pressure-tested for leaks as required in specifications. All system piping should be thoroughly cleaned, flushed, drained and refilled before the radiant panels are connected into the system.

With boiler in operation and circulators on, set control valves to full flow position. Flow in excess of 0.4 GPM per circuit is required to push the air out of the tubing and interconnects on the panel. Gradually bring the system to design temperature. The actual temperature drop through the panel will only be as designed when building is under design load. Balancing should be done for the radiant ceiling system during a cloudy day in the wintertime. After balancing, return the control valves to automatic operation.

**AR-X PANEL INSULATION, START-UP, PSYCHIATRIC & SECURITY USE**

The Airtite/Steel Ceilings, Inc. Security System consists of the linear extruded radiant panel construction with security features as described below.

The edge clips and center clips for attaching the back channel to the face plates are provided with holes.

After assembling the extrusions with cross-braces and clips use a #6-20 x 5/8” self-tapping screw with flat head through the holes of the clips and flanges of extrusions and cross-braces. Between the panel and the structure use either angle or channel fastened to the structure and to the braces on the back of the panel by use of the same #6-20 x 5/8” screws or by welding to the cross-channel and structure.

The wall-channel should be securely fastened to the structure and the panels placed between angles to assure that the panels cannot be pushed up. The hold downs can be the angles mentioned previously. The spacing of the braces and the number of screws through the clips depends on how much security is required by the application (hospital psychiatric wards to maximum security prison applications).
AR-X MAINTENANCE FOR HYDRONIC RADIANT HEATING/CoolING PANELS

MAINTENANCE

Maintenance is normally limited to cleaning of the panel face as required. Since there are no moving parts nothing else is required.

CLEANING PANEL FACE

*Dirt, scratches, abrasions or stains*

Loose dirt—such as ordinary dust—should be removed from the surface of the panel with a soft brush or vacuum cleaner. The panel may be washed using a mild detergent cleaner applied with a cellulose sponge. The sponge should hold just enough solution to adequately wet the surface. The edge of the sponge can be used to clean out grooves. Rinse the panel with a damp sponge of clean rinse water. The rinse water should be changed frequently to avoid streaking.

<table>
<thead>
<tr>
<th>CAUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DO NOT USE AN ABRASIVE CLEANER ON THE PAINTED SURFACE. DO NOT SLOSH EXCESSIVE WATER UP IN THE CEILING, AS IT MAY GO INTO PANEL JOINTS AND CAUSE DISCOLORATION OR LOOSENING OF PAINT FINISH.</strong></td>
</tr>
</tbody>
</table>

Removing small scratches, abrasions, stains, etc. may be accomplished by use of a solvent such as trichlorothane or trichloroethylene on a soft white cloth. Use caution not to remove the paint. Use only a small amount. Be sure the follow label directions when using these solvents.

PAINTING

Tiny scratches should be feathered in with a fine artist's brush. Touch up spray paint can be supplied by Steel Ceilings, Inc.

All surfaces should be thoroughly cleaned prior to repainting. It is recommended that a flat oil base paint be used. Metallic finishes should not be applied to the Airtite radiant ceiling because they have a low emissivity and therefore will reduce the radiant performance of the ceiling. The painter should test a sample of the paint in an inconspicuous place to assure compatibility of the new and old surfaces. Electrostatic paint spraying will normally produce the best results.
Steel Ceilings, Inc. has developed a product which consists of a linear air bar diffuser integrated into an extruded aluminum radiant panel.

This combination of air diffuser and radiant panel makes for a narrower, more aesthetic assembly, utilizing the sides of the radiant panel for the vertical sides of the diffuser.

This unique assembly lends itself to longer, continuous extruded air bar/radiant panels, which in many cases extend wall-to-wall without joints. The combination increases the delivered air temperature and the heat output from the panel. There can be as much as a 35% increase in total heating capacity. The pattern controller can be located anywhere along the air slot with supply plenums installed directly above the diffuser section. Blank-offs are used where there is no diffuser giving a continuous slot appearance.

The integral air pattern controllers can be 12" to 60" long and will allow the airstream to be vectored for left, right, or vertical airflow distribution. As with other extruded radiant panels, the design is similar to AR-X systems, having the same piping advantages and flexibility. For radiant panel design, refer to the extruded design procedure outlined in the AR-X extruded panel section.

In conclusion, this combined product takes up less space, provides better comfort, and enhances the appearance of the ceiling. This combination diffuser panel can be provided and installed at lower costs than separate heating and linear air diffuser systems.
AR-D DIFFUSER PANEL
WITH CENTER SLOTTED AIR DIFFUSER

Typical installation

Standard finish is white.
Nominal sizes with centered diffuser: 12", 20", 22", 24"

Integral pattern controllers are on 48" or 24" centers, which allow the air stream to be vectored left and right for horizontal and vertical air flow.
AR-D DIFFUSER PANEL
WITH OFFSET SLOTTED AIR DIFFUSER

- Standard finish is white.
- Nominal sizes with off-center diffuser: 12”, 16”, 17”, 18”, 19”, 20”, 21”, 22”, 23”, 24”

Integral pattern controllers are on 48” or 24” centers, which allow the air stream to be vectored left and right for horizontal and vertical air flow.
AR-D ENERGY EFFICIENCY: PERIMETER HEATING OUTPUT (BTUH/LF)

Table performance values from certified curves. Total certified output shown is per lineal foot of panel at the perimeter of the space. Output is based on 70°F air temperature; 67°F average unheated surface temperature (A.U.S.T) with one inch of 3/4” PCF unfaced fiberglass batt insulation on top of the panel, and natural convection. Actual output with minimum ventilation significantly increases panel output.

For Diffuser Panel with 1-1/2” slot width

<table>
<thead>
<tr>
<th>MEAN WATER TEMPERATURE (°F)</th>
<th>PANEL WIDTH</th>
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</thead>
<tbody>
<tr>
<td>120</td>
<td>77</td>
</tr>
<tr>
<td>125</td>
<td>90</td>
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<tr>
<td>130</td>
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<tr>
<td>215</td>
<td>329</td>
</tr>
<tr>
<td>220</td>
<td>332</td>
</tr>
</tbody>
</table>

* Diffuser slot not centered in panel.

For performance when air is being supplied through diffuser, use these multiplier values (delivered air temperature must be below room temperature):

- If air is delivered through 25% of total slot length, **multiplier is 1.20**
- If air is delivered through 50% of total slot length, **multiplier is 1.25**
- If air is delivered through 75% of total slot length, **multiplier is 1.30**
- If air is delivered through 100% of total slot length, **multiplier is 1.35**
AR-D PERFORMANCE DATA:
SINGLE SLOT DIFFUSER PANEL

Table performance values from certified curves. Total certified output shown is per lineal foot of panel at the perimeter of the space. Output is based on 70°F air temperature; 67°F average unheated surface temperature (A.U.S.T) with one inch of 3/4" PCF unfaced fiberglass batt insulation on top of the panel, and natural convection. Actual output with minimum ventilation significantly increases panel output.

For Diffuser Panel with 1-1/2” slot width

<table>
<thead>
<tr>
<th></th>
<th>2 FT.</th>
<th>4 FT.</th>
<th>5 FT.</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIRFLOW (CFM)</td>
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<tr>
<td>40</td>
<td>70</td>
<td>100</td>
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<tr>
<td>TOTAL PRESSURE (IN./H₂O)</td>
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<tr>
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<td>0.025</td>
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<tr>
<td>STATIC PRESSURE (IN./H₂O)</td>
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<td>NOISE*</td>
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<tr>
<td>&lt;15</td>
<td>&lt;15</td>
<td>18</td>
<td>25</td>
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<tr>
<td>THROW**</td>
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<tr>
<td>3-7-13</td>
<td>3-8-16</td>
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<td>5-14-18</td>
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<td>AIRFLOW (CFM)</td>
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<tr>
<td>STATIC PRESSURE (IN./H₂O)</td>
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<td>4-9-18</td>
<td>5-12-19</td>
<td>6-16-21</td>
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<tr>
<td>AIRFLOW (CFM)</td>
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<tr>
<td>90</td>
<td>150</td>
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<td>270</td>
</tr>
<tr>
<td>TOTAL PRESSURE (IN./H₂O)</td>
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<tr>
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<td>0.027</td>
<td>0.054</td>
<td>0.089</td>
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<td>0.006</td>
<td>0.016</td>
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<tr>
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<tr>
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<td>16</td>
<td>23</td>
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<tr>
<td>THROW**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-19-17</td>
<td>5-10-18</td>
<td>6-14-20</td>
<td>7-17-23</td>
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</tbody>
</table>

* Noise criteria (NC) was obtained by subtracting 10 dB room effect from the sound power level data

** Throw distances are given in feet and are for terminal velocities of 50, 100 and 150 FPM. The throw data values were obtained using isothermal air conditions.
AR-D SAMPLE SPECIFICATION

DIVISION 23-80 Decentralized HVAC Equipment

PART 1 – GENERAL

1.1 Scope
• Furnish and install Steel Ceilings, Inc. Airtite Radiant Ceiling system AR-D Linear Diffuser Panel

1.2 Related Sections
• Section 23 30 00 – HVAC Air Distribution
• Section 09 58 00 – Integrated Ceiling Assemblies

1.3 Reference
• Work under this section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions and sections under Division 01 General Requirements
• American Society for Testing and Materials
• C635 Standard specifications for the manufacture, performance and testing of metal suspension systems for acoustical tile and lay-in panel ceilings
• C636 Standard practice for installation of metal ceiling suspension systems for acoustical tile and lay-in panels
• E84 Test method for surface burning characteristics of building materials
• CISCA Ceilings and Interior Systems Construction Association

1.4 Submittals
• Provide product data sheets listing dimensions, style, edge detail, perforation pattern, finish and thermal performance
• Alternates require prior approval no later than 21 days prior to bid date. In addition to the requirements above, submittals for approved alternates must include samples of actual products to be substituted together with test certificates supporting performance claims, a mock up and a written warranty.

1.5 Project Conditions
• Area to receive ceiling systems shall be protected from the direct weather
• Wet trades work shall be complete and dry prior to installation of ceiling system

1.6 Attic Stock
• Provide 2% of the ceiling system area materials to be used as attic stock

1.7 Performance
• Materials and installation must comply with local building code and regulations
• Material should be stored and handled in accordance with CISCA’s Acoustical Ceilings – Use and Practices
• Material to comply with CISCA’s Metal Ceilings Technical Guidelines.
• There are no special seismic requirements

PART 2 – PRODUCTS

2.1 Manufacturer
• Steel Ceilings, Inc. Airtite Radiant panels manufactured in Johnstown, OH; www.steelceilings.com

2.2 Materials
  2.2.1 Panels
• Radiant heating panels/air diffuser assembly shall be complete with:
  • Extruded aluminum radiant panels. Radiant panel to have a U-shaped, extruded saddle for the copper tube. Saddle shall be formed in a manner to cover more than half of the copper tube for increased thermal performance, and to eliminate any separation of copper and aluminum. The use of adhesives, or hold-down clips or cap strips to attach copper tubing to the aluminum is not acceptable. Separate diffuser assemblies installed in radiant panels are not acceptable.
  • The sides of the 1.5” slot diffuser bar shall be formed from the sides of the radiant extrusion. Pattern controller and all internal diffuser parts are to be extruded aluminum for equal expansion of assembly and shall be designed and rated for total pressure, static pressure, N.C. (noise criteria) and throw at CFM ratings. Diffuser panel assembly shall have been previously tested for radiant and air-side performance.
Sample specification continued

- Panels made up of multiples of 4-, 5-, 6-inch extrusions to match required width as indicated on the drawing and in the specifications. Factory-applied two coats of sand textured polyester powder coat paint in manufacturer's standard white color to the finished side of the panel: diffuser interior parts to be black.
- Panel water tubes to be 0.504” I.D. seamless copper. Panel water tubes shall be mechanically bonded to the aluminum panels, and a non-hardening, heat-conductive paste shall be applied between the copper tube and the extruded aluminum saddle.
- Face configuration: fluted (0.020” flutes) plate thickness not less than 0.100”
- Panel size: All panels shall be the minimum width indicated on the drawing and per the sectional detail shown on the drawings

2.2.2 Performance
- Panels shall provide heating and cooling as laid out in the engineer’s requirements

PART 3 – EXECUTION

3.1 Examination
- Installer must inspect the area that is to receive the metal ceiling system for conditions that may affect the installation and notify, in writing, any conditions that must be rectified before commencing
- Installer should inspect all materials delivered to the job site for shipping damage and notify, in writing, Steel Ceilings, Inc. if any damage is found

3.2 Installation
- All material should be stored in a dry and protected area
- All work above the ceiling shall be completed before proceeding with this installation
- All wet work shall be completed and thoroughly dry before proceeding with this installation
- Install the ceiling system in accordance with the manufacturer’s recommendations and the approved shop drawings
- Panels shall be free from defects
- Damaged panels shall be removed and replaced

3.3 Connections
- Piping installation requirements are specified in other Division 23 Sections. General arrangement of piping, fittings, and specialties are indicated on the drawings.
- In order to improve the hydronic performance and efficiency connect the copper tubing to the supply line with shut-off valve, strainer, control valve, and union or flange. Connect the return line with balancing valve and union or flange.

3.4 Field Quality Control
- Perform the following leak tests and inspections and prepare test reports:
  - Leak Test: After installation, fill lines with clean dry air check for air loss and/or leaks. Repair leaks and retest with air until there are no leaks.
  - Leak Test with water: Once the initial leak test has been completed re-test the system with water
  - Operational Test: After electrical circuitry has been energized, start units to conform to proper unit operation
  - Test and adjust controls and safeties: Replace damaged and malfunctioning controls and equipment

3.5 Cleaning and Protection
- Clean all visible surfaces of equipment; touch up as required
- Protect all units before, during and after installation. Damaged panels due to improper protection or mishandling is the responsibility of the installer.
RECEIVING AND STORAGE:
The extrusions should be stored in a clean, dry place protected from the weather. They should be stored in the original shipping cartons until they are ready to be assembled and installed in the ceiling. Do not store other materials on top of the cartons. It is suggested that the extrusions be stored at room temperature for twenty four hours prior to installation.

MOUNTING
All necessary and prudent safety procedures should be followed while handling, preparing and installing the radiant panels.

The preferred mounting suspension on an outside wall is angle molding. If severe irregularities occur in the wall it may be necessary to true up the wall. Do not attempt to bend the angle or panel to conform to the wall. The inside suspension member can be a main runner or any other suspension detail which offers uniform support. If exposed grid is used, standard 15/16” wide main runner is preferred. Pop rivets should not be used on the suspension system for the radiant panel.

The inside and outside suspension members must be parallel. The assembled panel cannot be bent or cut to conform to non-parallel or non-straight suspensions members. The spacing between the suspension members must be large enough to allow for panel installation and expansion during use. (Aluminum expands at the rate of 1-½ inches per hundred feet, per 100° F temperature change). The spacing between the suspension members must be small enough so that the panel cannot fall out of the ceiling even if it rests tight against either suspension member.

Panel installation assumes that the wall channel has a 1” lower flange and the main runner is 15/16” wide. Each panel should be supported at the ends and in the center with a hanger wire attached to the back of the panel. Where heavy draperies or other materials are to be fastened to the panel, additional support of the panel is required. Hold-downs may be used as required in areas where the panel does not lay firmly against the support system.

When installing panels (except for special assemblies) the male tang on the panel should always face the outside wall.

PANEL ASSEMBLY REQUIREMENTS
The Airtite AR-D extruded panels are part of the finished surface within the occupied space. The face must be protected at all times from damage. White gloves should be worn by all personnel touching the panel to eliminate fingerprint marks. The gloves should be discarded once they become soiled.

All panels should be assembled on a workbench at least as large as the largest panel to be used on the job. This bench is essential for simple and efficient assembly. The bench should be clean and use of a protective material is recommended. The protective material should be of a color to show dirt so it can be changed when soiled. We recommend white paper.

CONNECTION OF THE COPPER TUBING
For interconnecting panel tubing in long runs Airtite/Steel Ceilings, Inc. offers a 360° expansion loop pre-sized to fit the panel tubing without the need for fittings. Return U-bends sized for 2”, 4”, 5”, or 6” O.C. spacing can also be provided.

The 360° expansion loop has been designed for attachment to copper tube on the panel after the tube has been raised with the Airtite tube lifting/sizing tool. 3/8” type “M” or “L” (0.500”O.D.) tubing can be used for supply and return connections, interconnects, U-bends, or to pipe around columns. The ends of the tubing on the back of the panel are sized to accept 0.500” O.D. tubing without the need for fittings.

If the pressure drop is excessive when 3/8” “M” or “L” is used then it is recommended that 360° interconnects, U-bends, and “around column” interconnects be purchased from Airtite/Steel Ceilings, Inc. which are produced from special tubing sized to accept the panel tubing without the need for fittings. Panels are supplied from the factory with the tubing terminating 4-5/16”
from the end of the panel. This will allow for proper fit of the 360 degree interconnects and working space for the U-bends and supply and return connections.

The ends of the copper tubing should be lifted from the back of the panel while it is still on the workbench. The combination tube lifting/sizing tool should be used for this purpose. The procedure to follow when using the tool is:

1. Use the forked end of the tool to remove the plastic plugs from the ends of the tube. The tube then must be lifted out of the extrusion using the tool mentioned above.

2. Insert the male mandrel of the tube lifting/sizing tool into the copper tube. Take care that the mandrel is fully inserted into the tube as partial insertion may damage the tubing.

3. Push down on the raised end of the tool while holding the tool tight to the back of the panel until the sizing socket strikes the back of the tubing. The end is now bent up at the proper angle for the attachment of the 360° interconnects or U-bends.

When soldering the connection use specified materials making sure that each joint is well capped. Good piping practice should be followed. Take care to keep the flame from the torch away from the panel surface. Wipe the joints of excess flux after soldering, and pressure-test per specs. (Silver solder or brazing of the joints may be specified.)

INSULATION

An insulation blanket, if specified (usually 1” thick, 1-lb. density), should cover the entire back of the radiant panel. Cut the blanket to pass around the suspension wires and interconnecting piping. Make sure that the blanket abuts the adjacent blanket tightly. Do not place the insulation blanket over any incandescent or florescent light fixtures.

Interconnecting piping is not insulated unless specifically required by the specs. Airtite does not recommend insulating interconnecting piping.

START-UP

Each zone of panels should be pressure-tested for leaks as required in specifications. All system piping should be thoroughly cleaned, flushed, drained and refilled before the radiant panels are connected into the system.

With boiler in operation and circulators on, set control valves to full flow position. Flow in excess of 0.4 GPM per circuit is required to push the air out of the tubing and interconnects on the panel. Gradually bring the system to design temperature. The actual temperature drop through the panel will only be as designed when building is under design load. Balancing should be done for the radiant ceiling system during a cloudy day in the wintertime. After balancing return the control valves to automatic operation.
AR-D MAINTENANCE AND CLEANING

MAINTENANCE

Maintenance is normally limited to cleaning of the panel face as required. Since there are no moving parts nothing else is required.

CLEANING PANEL FACE

*Dirt, scratches, abrasions or stains*

Loose dirt—such as ordinary dust—should be removed from the surface of the panel with a soft brush or vacuum cleaner. The panel may be washed using a mild detergent cleaner applied with a cellulose sponge. The sponge should hold just enough solution to adequately wet the surface. The edge of the sponge can be used to clean out grooves. Rinse the panel with a damp sponge of clean rinse water. The rinse water should be changed frequently to avoid streaking.

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CAUTION

DO NOT USE AN ABRASIVE CLEANER ON THE PAINTED SURFACE. DO NOT SLOSH EXCESSIVE WATER UP IN THE CEILING, AS IT MAY GO INTO PANEL JOINTS AND CAUSE DISCOLORATION OR LOOSENING OF PAINT FINISH.

Removing small scratches, abrasions, stains, etc. may be accomplished by use of a solvent such as trichloroethylene or trichloroethylene on a soft white cloth. Use caution not to remove the paint. Use only a small amount. Be sure the follow label directions when using these solvents.

PAINTING

Tiny scratches should be feathered in with a fine artist’s brush. Touch up spray paint can be supplied by Steel Ceilings, Inc.

All surfaces should be thoroughly cleaned prior to repainting. It is recommended that a flat oil base paint be used. Metallic finishes should not be applied to the Airtite radiant ceiling because they have a low emissivity and therefore will reduce the radiant performance of the ceiling. The painter should test a sample of the paint in an inconspicuous place to assure compatibility of the new and old surfaces. Electrostatic paint spraying will normally produce the best results.
AR-M Modular Panels
Airtite AR-M modular panels are 2’ x 2’ and 2’ x 4’ formed metal .040-inch aluminum panels. These highly efficient lightweight radiant panels have six-pass sinuous coils metallurgically bonded (soldered) to the back of the aluminum panel.

The panels are sized to fit into standard ceiling grids and can be supplied in standard white, silk screened to match acoustical ceiling, or block-perforated. All panels come with a standard 1-inch-thick sheet of insulation. The perforated panels with insulation have excellent sound absorption.

AR-B Perforated Modular Panels
The AR-B panels are architectural perforated metal ceiling panels that can be designed for various suspension systems such as Torsion Spring, Lay-In, etc.

The panels can be provided in various sizes, metal, thicknesses and perforation patterns. Typical panels are fabricated with aluminum which provides the best heat transfer and hence the best radiant performance.

The AR-B panels are activated by bonding aluminum extrusions (heat transfer rails) incorporating integral sinuous copper coils to the back of the panels. Fleece can be installed between the extrusions for both appearance and noise reduction. With the fleece or other insulation (such as encapsulated fiberglass or recycled cotton), these architectural perforated panels can achieve high NRC values that exceed typical standard mineral tile ceilings. Flexible braided SST hoses with oxygen barrier and push fit fittings (ideal for installation and facilities personnel) are used to interconnect the panels and connect to the piping supply and return.

AR-M and AR-B Modular Panels
The panels can be installed in acoustical ceilings, recess-mounted in drywall or surface-mounted. In acoustic ceilings, the grid itself is able to support the panels which weigh less than 2 lbs. per square foot when filled with water without additional suspension. The panels are piped with ½” O.D. copper requiring no fittings for simple installation. The use of longer interconnecting piping allows for the panels to be pushed up out of the grid and moved over to gain access to the plenum above.

The highly durable polyester powder coat paint finish is scratch-resistant and easily cleaned.
SIX-PASS SINUOUS COIL ON BACK OF PANEL

ACOUSTICAL THERMAL INSULATION

SILK SCREEN FINISH

BLOCK-PERFORATED

SMOOTH
### AR-B AND AR-M HEATING PERFORMANCE AND PRESSURE DROP TABLE

**Heating performance**
Perimeter heating performance based on 70°F air temperature, 67°F A.U.S.T. and natural convection. One inch of three-quarter-pound density fiberglass insulation was placed on the top side of the panels.

**Pressure Drop**
Both panels and connecting tubing pressure drops must be included in the circuit pressure drop calculation.

*Flow rated below .5 GPM are not recommended.*

#### HEATING PERFORMANCE
*(SHOWN IN BTUH/PANEL)*

<table>
<thead>
<tr>
<th>PANEL TYPE</th>
<th>Perimeter 2’x4’</th>
<th>Interior 2’x4’</th>
<th>Perimeter 2’x2’</th>
<th>Interior 2’x2’</th>
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#### WATER PRESSURE DROP
*(SHOWN IN FT/PANEL EXCEPT FOR CONNECTING TUBE)*

<table>
<thead>
<tr>
<th>PANEL TUBING</th>
<th>GPM per circuit</th>
<th>2’x4’</th>
<th>2’x2’</th>
<th>3/8” Type L ft./100 ft.</th>
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**Mean Water Temperature (Degrees Fahrenheit)**
AR-B AND AR-M COOLING PERFORMANCE:

Cooling Performance for Modular Panels

<table>
<thead>
<tr>
<th>ROOM AIR TEMPERATURE (MINUS MWT °F)</th>
<th>INTERIOR ROOM</th>
<th>NO GLASS IN SUN OR FULLY SHAD ED GLASS AND WALL</th>
<th>25% CLEAR EXTERIOR WALL IN SUN</th>
<th>50% CLEAR EXTERIOR WALL IN SUN</th>
<th>75% CLEAR EXTERIOR WALL IN SUN</th>
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</tbody>
</table>
AR-B AND AR-M PANEL DESIGN

COOLING **2290 BTUH 72 SF 1.3 GPM**
HEATING **8841 BTUH @ 150 MWT 1.0 GPM**
MAX $\lambda P$ @ TWO CIRCUITS 0.65 GPM/CRT

At 0.65 GPM, pressure drop per modular panel is 0.37 ft. of water.
At 0.65 GPM, 3/8” L CU is 3.2 ft. of water/100’ CU

$\lambda P = 5$ panels: $5 \times 0.37 \text{ GPM/panel} + 22’-3/8” \text{ L CU} \times 3.2 \text{ ft. of water/100’ CU} = 2.55 \text{ ft. of water}

1.85 ft. of water + 7.04 ft. of water = 2.55 ft. of water

$\lambda P = 4$ panels: $4 \times 0.37 \text{ GPM/panel} + 35’-3/8” \text{ L CU} \times 3.2 \text{ ft. of water/100’ CU} = 2.66 \text{ ft. of water}

1.48 ft. of water + 1.12 ft. of water = 2.6 ft. of water

**PERIMETER 2’X4’**
@150° MWT
1140 BTUH/panel
3 panels
3420 total BTUH

**INTERIOR 2’X4’**
@150° MWT
905 BTUH/panel
6 panels
5430 total BTUH
AR-B AND AR-M TYPICAL PANEL LAYOUTS

Typical single panel hook-up

1/2” O.D. soft copper tubing (typical)

Typical two panel hook-ups

Typical multiple panel hook-ups
AR-B AND AR-M DESIGN PROCEDURE AND EXAMPLE

**DESIGN PROCEDURE**
The design of a radiant ceiling panel heating system should follow the usual guidelines of a closed water system. To design such a system, we need to find the following:

1. Calculate the heat loss per zone or room
2. Determine the number of 2’x2’ or 2’x4’ modular panels
3. Determine the panel layout and water flow
4. Calculate the water pressure drop based upon panel layout and piping arrangement

**DESIGN EXAMPLE: RECTANGULAR BUILDING**
Given conditions:
- 100 ft. x 150 ft. floor plan
- 12 ft. floor-to-floor
- Inside design = 72°F Dry Bulb
- Supply Water Temp = 180°F
- Return Water Temp = 160°F
- Heat loss for each floor = 175,000 BTUH

1. Calculate the heat loss per zone per lineal foot of perimeter and per zone.

   \[
   \text{Heat loss/LF of perimeter} = \frac{175,000 \text{ BTUH}}{500 \text{ LF}} = 350 \text{ BTUH/LF} \\
   \text{50 LF zone heat loss} = \frac{50 \text{ LF} \times 350 \text{ BTUH/LF}}{= 17,500 \text{ BTUH}}
   \]

2. Determine the number of panels
   The ceiling has a 2’x4’ grid layout. The perimeter performance of a 2’x4’ modular panel at 170°F mean water temperature = 1500 BTUH per panel.

3. Determine panel layout and water flow
   Based on either room size or zone size, determine modular arrangement. Therefore, a 50-ft. zone (circuit) without perimeter walls would have 12 – 2’x4’ modular panels in series.

   \[
   \text{Total GPM} = \frac{\text{Total BTUH/zone}}{500 \times \text{water temp. drop}\; ^\circ \text{F}} \\
   \text{500} = \frac{8.34 \text{ lbs/gal} \times 60 \text{ min/hr}}{}
   \]

   \[
   \text{GPM} = \frac{17,500 \text{ BTUH}}{1.75 \text{ GPM}} = \frac{500 \times 20^\circ \text{F}}{}
   \]

   This zone will be divided up into two circuits of six – 2’x4’ modular panels.

4. Calculate the water pressure drop based upon piping arrangement
   Each circuit of six – 2’x4’ modular panels would have a flow of .9 GPM per the pressure drop table.

   Per the pressure drop table, at .9 GPM shows .67 ft. of W.P.D. per panel.

   Pressure drop for the panels on this circuit:

   \[
   6 \times .67 = 4.02 \text{ ft. of water}
   \]

   Per the pressure drop table, for 3/8” L copper at .9 GPM shows 5.81 of WPD per 100 ft. of tube.

   Per example below, there will be 45 LF of 3/8” L copper:

   \[
   45 \times 5.81 = 2.61 \text{ ft. of water}
   \]

   Total pressure drop = 4.02 + 2.61

   = 6.34 ft. of water
AR-B AND AR-M SAMPLE SPECIFICATION
FOR RADIANT HEATING/COOLING PANELS

DIVISION 23- 80 Decentralized HVAC Equipment

PART 1 – GENERAL

1.1 Scope
• Furnish and install Steel Ceilings, Inc. Airtite Radiant Ceiling system (Modular Panel A or Modular Panel B)

1.2 Related Sections
• Section 20 07 00 – Mechanical Systems Insulation
• Section 23 05 94 – Water Systems Test Adjust Balance
• Section 23 21 16 – Pipe and Pipe Fittings
• Section 23 21 18 – Valves
• Section 23 01 00 – Operation and Maintenance of HVAC Systems
• Section 23 05 00 – Common Work Results for HVAC
• Section 23 09 00 – Instrumentation and Control for HVAC
• Section 23 20 00 – HVAC Piping and Pumps
• Section 23 30 00 – HVAC Air Distribution

1.3 Reference
• Work under this section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions and sections under Division 01 General Requirements
• American Society for Testing and Materials
• C635 Standard specifications for the manufacture, performance and testing of metal suspension systems for acoustical tile and lay-in panel ceilings
• C636 Standard practice for installation of metal ceiling suspension systems for acoustical tile and lay-in panels
• E84 Test method for surface burning characteristics of building materials
• CISCA Ceilings and Interior Systems Construction Association

1.4 Submittals
• Provide product data sheets listing dimensions, style, edge detail, perforation pattern, finish and thermal performance
• Alternates require prior approval no later than 21 days prior to bid date. In addition to the requirements above, submittals for approved alternates must include samples of actual products to be substituted together with test certificates supporting performance claims, a mock up and a written warranty.

1.5 Project Conditions
• Area to receive ceiling systems shall be protected from the direct weather
• Wet trades work shall be complete and dry prior to installation of ceiling system

1.6 Attic Stock
• Provide 2% of the ceiling system area materials to be used as attic stock

1.7 Performance
• Materials and installation must comply with local building code and regulations
• Material should be stored and handled in accordance with CISCA’s Acoustical Ceilings – Use and Practices
• Material to comply with CISCA’s Metal Ceilings Technical Guidelines.
• There are no special seismic requirements

PART 2 – PRODUCTS

2.1 Manufacturer
• Steel Ceilings, Inc. Airtite Radiant panels manufactured in Johnstown, OH: www.steelceilings.com

2.2 Materials

2.2.1 Panels
• AR-M and AR-B panels shall be constructed of aluminum sheet stock with the finished sizes of 2’ x 2’ and 2’ x 4’ Other sizes are available.

2.2.2 Modular Panels AR-M & AR-B
• Approved Manufacturers:
  • Steel Ceilings, Inc. of Johnstown, OH
  • Alternates or approved equals are acceptable if and only if a mock-up and witness test is performed to demonstrate that the substitution meets design criteria
• The modular radiant panels are designed to radiate heat to the zone below or absorb heat (cooling mode)
• AR-B Modular radiant panels shall use heat sinks on the back of an aluminum ceiling panel to transfer heat between the copper tubing and the panel face
• AR-B panels are fabricated with ASTM B75 ½” nominal copper tubing. Water connections shall be one end only. Water connections shall be suitable for solder, compression fittings, push-on fittings or threaded connections.
• AR-M panels are fabricated with 0.500” I.D. copper tubing metallurgically bonded to the back of the panel. The ends of the tubing are sized to accept ¾” type M or L soft copper tubing.
• All visible components are powder-coated with a high-emissivity polyester powder for efficient radiative properties. The polyester powder provides a durable and easy to clean surface treatment.
• The standard color provided is Steel Ceilings, Inc. white, other colors are available upon request
• Water connections shall be shipped sealed to limit the introduction of dust and dirt during shipping and construction
• Accessories
  • Braided stainless steel connections hoses (12” & 18”) with oxygen barrier liner can be provided on request
  • Isolation control valves can be provided on request
  • Header assemblies can be provided on request
  • Fiberglass 1” x 1 pcf to be supplied for insulation of the back of the panel

2.2.5 Performance
• Panels shall provide heating and cooling as laid out in the engineer’s requirements

3.2 Installation
• All material should be stored in a dry and protected area
• All work above the ceiling shall be completed before proceeding with this installation
• All wet work shall be completed and thoroughly dry before proceeding with this installation
• Install the ceiling system in accordance with the manufacturer’s recommendations and the approved shop drawings
• Panels shall be free from defects
• Damaged panels shall be removed and replaced

3.3 Connections
• Piping installation requirements are specified in other Division 23 Sections. General arrangement of piping, fittings, and specialties are indicated on the drawings.
• In order to improve the hydronic performance and efficiency connect the copper tubing to the supply line with shut-off valve, strainer, control valve, and union or flange. Connect the return line with balancing valve and union or flange.

3.4 Field Quality Control
• Perform the following leak tests and inspections and prepare test reports:
  • Leak Test: After installation, fill lines with clean dry air check for air loss and/or leaks. Repair leaks and retest with air until there are no leaks.
  • Leak Test with water: Once the initial leak test has been completed re-test the system with water
  • Operational Test: After electrical circuitry has been energized, start units to conform to proper unit operation
  • Test and adjust controls and safeties: Replace damaged and malfunctioning controls and equipment

3.5 Cleaning and Protection
• Clean all visible surfaces of equipment; touch up as required
• Protect all units before, during and after installation. Damaged panels due to improper protection or mishandling is the responsibility of the installer.
AR-B AND AR-M INSTALLATION

RECEIVING AND STORAGE:
The extrusions should be stored in a clean, dry place protected from the weather. They should be stored in the original shipping cartons until they are ready to be assembled and installed in the ceiling. Do not store other materials on top of the cartons. It is suggested that the extrusions be stored at room temperature for twenty four hours prior to installation.

MOUNTING
All necessary and prudent safety procedures should be followed while handling, preparing and installing the radiant panels.

The preferred mounting suspension on an outside wall is angle molding. If severe irregularities occur in the wall it may be necessary to true up the wall. Do not attempt to bend the angle or panel to conform to the wall. The inside suspension member can be a main runner or any other suspension detail which offers uniform support. If exposed grid is used, standard 15/16” wide main runner is preferred. Pop rivets should not be used on the suspension system for the radiant panel.

The inside and outside suspension members must be parallel. The assembled panel cannot be bent or cut to conform to non-parallel or non-straight suspensions members. The spacing between the suspension members must be large enough to allow for panel installation and expansion during use. (Aluminum expands at the rate of 1-½ inches per hundred feet, per 100° F. temperature change). The spacing between the suspension members must be small enough so that the panel cannot fall out of the ceiling even if it is rests tight against either suspension member.

Additional cross-tees should be installed at a center-to-center spacing equal to the nominal panel length. These cross-tees should be cut so as to maintain the distance between the wall-channel and the main runner. The length of the cross-tee should be slightly less than the wall-channel to main runner spacing to allow for expansion. The face of the cross-tee, wall-channel and main runner should be flush for a more attractive job.

PANEL ASSEMBLY REQUIREMENTS
The Airtite AR-M and AR-B panels are part of the finished surface within the occupied space. The face must be protected at all times from damage. White gloves should be worn by all personnel touching the panel to eliminate fingerprint marks. The gloves should be discarded once they become soiled.

INSULATION
An insulation blanket, if specified (usually 1” thick, 1-lb. density), should cover the entire back of the radiant panel. Cut the blanket to pass around the suspension wires and interconnecting piping. Make sure that the blanket abuts the adjacent blanket tightly. Do not place the insulation blanket over any incandescent or florescent light fixtures.

Interconnecting piping is not insulated unless specifically required by the specs. Airtite does not recommend insulating interconnecting piping.

START-UP
Each zone of panels should be pressure-tested for leaks as required in specifications. All system piping should be thoroughly cleaned, flushed, drained and refilled before the radiant panels are connected into the system.

With boiler in operation and circulators on, set control valves to full flow position. Flow in excess of 0.4 GPM per circuit is required to push the air out of the tubing and interconnects on the panel. Gradually bring the system to design temperature. The actual temperature drop through the panel will only be as designed when building is under design load. Balancing should be done for the radiant ceiling system during a cloudy day in the wintertime. After balancing return the control valves to automatic operation.
AR-B AND AR-M MAINTENANCE AND CLEANING

MAINTENANCE

Maintenance is normally limited to cleaning of the panel face as required. Since there are no moving parts nothing else is required.

CLEANING PANEL FACE

Dirt, scratches, abrasions or stains

Loose dirt—such as ordinary dust—should be removed from the surface of the panel with a soft brush or vacuum cleaner. The panel may be washed using a mild detergent cleaner applied with a cellulose sponge. The sponge should hold just enough solution to adequately wet the surface. The edge of the sponge can be used to clean out grooves. Rinse the panel with a damp sponge of clean rinse water. The rinse water should be changed frequently to avoid streaking.

CAUTION

DO NOT USE AN ABRASIVE CLEANER ON THE PAINTED SURFACE. DO NOT SLOSH EXCESSIVE WATER UP IN THE CEILING, AS IT MAY GO INTO PANEL JOINTS AND CAUSE DISCOLORATION OR LOOSENING OF PAINT FINISH.

Removing small scratches, abrasions, stains, etc. may be accomplished by use of a solvent such as trichloroethylene or trichloroethylene on a soft white cloth. Use caution not to remove the paint. Use only a small amount. Be sure the follow label directions when using these solvents.

PAINTING

Tiny scratches should be feathered in with a fine artist’s brush. Touch up spray paint can be supplied by Steel Ceilings, Inc.

All surfaces should be thoroughly cleaned prior to repainting. It is recommended that a flat oil base paint be used. Metallic finishes should not be applied to the Airtite radiant ceiling because they have a low emissivity and therefore will reduce the radiant performance of the ceiling. The painter should test a sample of the paint in an inconspicuous place to assure compatibility of the new and old surfaces. Electrostatic paint spraying will normally produce the best results.
The AR-L and AR-C are high-capacity radiant cooling linear systems based on the principles of radiant technology. By separating the linear radiant elements with a gap, the AR-L and AR-C couples the radiant cooling effects of standard radiant panels with a convective component. Chilled AR-L and AR-C ceilings create natural convection by cooling the surrounding air as it passes over the surface facing the plenum.

As the denser air falls into the occupied zone, warmer air is pulled over the element, incorporating convective cooling capacity of the AR-L and AR-C with the radiant capacity of the cool surface (see below). The approximate breakdown of heat transfer of the chilled radiant system is 30% by thermal radiation and 70% by natural convection.

When used for heating the AR-L and AR-C transfers heat mainly through thermal radiation with room surfaces, where it increases the average unheated surface temperature of the room. As warmer air rises past the heated sails, natural convection occurs, which results in warmer return air.

**ENERGY EFFICIENCY**

The specific heat capacity of water is four times higher than air. This means that the energy that 1-cubic-foot of water can remove requires an equivalent of 3,480-cubic-foot of air (due to the density of water versus air). Therefore, to remove a given amount of heat from a building, less than 25% of the transport energy is required to remove the same amount of heat compared to an all-air system. Because AR-L and AR-C are water-only systems, they can handle the sensible portion of a building load and must be paired with a fresh air system for ventilation and latent load removal.

**MODELS**

The AR-L and AR-C profiles cover both a flat and a concave face as shown at left. The surface profile is dependent on the application, need for excellent aesthetics and broad design flexibility. Contact Steel Ceilings for more information on which profile to use for your application.

AR-L and AR-C are designed to allow air movement through openings between the slats, increasing the capacity of the unit and providing an effective means of dealing with sensible cooling loads. AR-L and AR-C can be installed in a variety of applications including full or cloud ceiling areas.
The visible surfaces of the aluminum extrusion and bracing are usually painted white. Optional custom colors are available which meet the emissivity requirements.

**TYPICAL DESIGN**
The precision extruded aluminum profiles are optimally formed with one or two conduction rails to accommodate copper tube and provide cooling fins which are rounded off at the outer end. The extruded profiles are 5” wide with a typical length of 160” long.

The gap between the extruded profiles is typically 1.0 inches with up to 8 profiles wide per assembled unit. The copper tube is press-fit into the conducting rails of the extrusion, ensuring continuous contact between the copper and the aluminum along the entire length and providing optimal heat transfer. Copper tubing with a 0.625” O.D. (1/2” nominal) is used in the fabrication of the system.

The connections between the modules and the distribution lines can be made via copper tubing and/or flexible metal hoses with stainless steel sheathing. After installation, the entire system must be checked for leaks. The cold water inflow temperature should be selected so that this never falls below the dew point, which would create condensation. It is recommended that a dew point sensor be incorporated in the overall design of the system to adjust the water temperature.

Special design options such as folding modules, sprinklers, lighting openings, air intake, etc. are available.

**ACCESS PANEL DESIGN**
Panels can be designed into the AR-L and AR-C modules to allow access to the plenum area. The access panels are designed with torsion springs allowing the panel to be pulled straight down without any special tools and swung out of the way. Access panels can have the same radiant heating and cooling capacity as a fixed panel or be a non-active panel and can be placed within the ceiling system where needed.
AR-L AND AR-C PERFORMANCE DATA

<table>
<thead>
<tr>
<th>AR-L</th>
<th>AR-C</th>
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<tbody>
<tr>
<td><img src="image1" alt="AR-L Specific Cooling Capacity" /></td>
<td><img src="image2" alt="AR-C Specific Cooling Capacity" /></td>
</tr>
<tr>
<td><img src="image3" alt="AR-L Correction Factor" /></td>
<td><img src="image4" alt="AR-C Correction Factor" /></td>
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</tbody>
</table>

**AR-L & AR-C PERFORMANCE DATA**

**AR-L**
- **BTUH/FT.²** vs. Room Temp - MWT in °F (based on 30% AR-L area vs. open area)
- **AR-L Specific Cooling Capacity**
- **AR-L Correction Factor**

**AR-C**
- **BTUH/FT.²** vs. Room Temp - MWT in °F (based on 30% AR-C area vs. open area)
- **AR-C Specific Cooling Capacity**
- **AR-C Correction Factor**
AR-L AND AR-C SAMPLE SPECIFICATION

DIVISION 23- 80 Decentralized HVAC Equipment

PART 1 – GENERAL

1.1 Scope
• Furnish and install Steel Ceilings, Inc. Airtite Radiant Ceiling system AR-L and AR-C Radiant + Convection Panel

1.2 Related Sections
• Section 20 07 00 – Mechanical Systems Insulation
• Section 23 05 94 – Water Systems Test Adjust Balance
• Section 23 21 16 – Pipe and Pipe Fittings
• Section 23 21 18 – Valves
• Section 23 01 00 – Operation and Maintenance of HVAC Systems
• Section 23 05 00 – Common Work Results for HVAC
• Section 23 09 00 – Instrumentation and Control for HVAC
• Section 23 20 00 – HVAC Piping and Pumps
• Section 23 30 00 – HVAC Air Distribution

1.3 Reference
• Work under this section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions and sections under Division 01 General Requirements
• American Society for Testing and Materials
• C635 Standard specifications for the manufacture, performance and testing of metal suspension systems for acoustical tile and lay-in panel ceilings
• C636 Standard practice for installation of metal ceiling suspension systems for acoustical tile and lay-in panels
• E84 Test method for surface burning characteristics of building materials
• CISCA Ceilings and Interior Systems Construction Association

1.4 Submittals
• Provide product data sheets listing dimensions, style, edge detail, perforation pattern, finish and thermal performance
• Alternates require prior approval no later than 21 days prior to bid date. In addition to the requirements above, submittals for approved alternates must include samples of actual products to be substituted together with test certificates supporting performance claims, a mock up and a written warranty.

1.5 Project Conditions
• Area to receive ceiling systems shall be protected from the direct weather
• Wet trades work shall be complete and dry prior to installation of ceiling system

1.6 Attic Stock
• Provide 2% of the ceiling system area materials to be used as attic stock

1.7 Performance
• Materials and installation must comply with local building code and regulations
• Material should be stored and handled in accordance with CISCA’s Acoustical Ceilings – Use and Practices
• Material to comply with CISCA’s Metal Ceilings Technical Guidelines.
• There are no special seismic requirements

PART 2 – PRODUCTS

2.1 Manufacturer
• Steel Ceilings, Inc. Airtite Radiant panels manufactured in Johnstown, OH: www.steelceilings.com

2.2 Materials

2.2.1 Panels
• AR-C & AR-L panels shall be constructed of aluminum extrusions providing panel widths from 4” up to 36” wide and up to 16’ long. Painted with polyester powder, Steel Ceilings, Inc. white; other colors available.

2.2.2 Linear Panels AR-C & AR-L
• Approved manufacturers:
• Steel Ceilings, Inc. of Johnstown, OH
• Alternates or approved equals are acceptable if, and only if, a mock-up and witness test is performed to demonstrate that the substitution meets design criteria

Continued
• AR-C & AR-L linear panels shall be manufactured from extruded aluminum with an integrated heat sink(s) on the back to transfer heat between the copper tube(s) and the panel face.
• The radiant linear ceiling panel shall be manufactured of extruded aluminum with angle cross braces attached by sheet metal screws. Each section shall have at least one integral heat saddle with a copper tube mechanically reformed into the heat saddle such that the tube is in intimate engagement with the heat saddle, which shall extend more than half way around the tube. A non-hardening conductive medium shall be applied between the copper tube and the aluminum extrusion. The use of adhesive, clips, or screws that attach the copper tube to the extrusion will not be acceptable.
• Water tubes shall consist of ASTM B75 ½” nominal copper tubing. Water connections shall be one end only. Water connections shall be suitable for solder, compression fittings, push-on fittings or threaded connections.
• All visible components are powder-coated with a high-emissivity polyester powder for efficient radiative properties. The polyester powder provides a durable and easy to clean surface treatment.
• The standard color provided is Steel Ceilings, Inc. white; other colors are available upon request
• Water connections shall be shipped sealed to limit the introduction of dust and dirt during shipping and construction

Accessories:
• Braided stainless steel connections hoses (12” & 18”) with oxygen barrier liner can be provided on request
• Isolation control valves can be provided on request
• Header assemblies can be provided on request

2.2.3 Performance
• Panels shall provide heating and cooling as laid out in the engineer’s requirements

PART 3 – EXECUTION
3.1 Examination
• Installer must inspect the area that is to receive the metal ceiling system for conditions that may affect the installation and notify, in writing, any conditions that must be rectified before commencing
• Installer should inspect all materials delivered to the job site for shipping damage and notify, in writing, Steel Ceilings, Inc. if any damage is found

3.2 Installation
• All material should be stored in a dry and protected area
• All work above the ceiling shall be completed before proceeding with this installation
• All wet work shall be completed and thoroughly dry before proceeding with this installation
• Install the ceiling system in accordance with the manufacturer’s recommendations and the approved shop drawings
• Panels shall be free from defects
• Damaged panels shall be removed and replaced

3.3 Connections
• Piping installation requirements are specified in other Division 23 Sections. General arrangement of piping, fittings, and specialties are indicated on the drawings.
• In order to improve the hydronic performance and efficiency connect the copper tubing to the supply line with shut-off valve, strainer, control valve, and union or flange. Connect the return line with balancing valve and union or flange.

3.4 Field Quality Control
• Perform the following leak tests and inspections and prepare test reports:
  • Leak Test: After installation, fill lines with clean dry air check for air loss and/or leaks. Repair leaks and retest with air until there are no leaks.
  • Leak Test with water: Once the initial leak test has been completed re-test the system with water
  • Operational Test: After electrical circuitry has been energized, start units to conform to proper unit operation
  • Test and adjust controls and safeties: Replace damaged and malfunctioning controls and equipment

3.5 Cleaning and Protection
• Clean all visible surfaces of equipment; touch up as required
• Protect all units before, during and after installation. Damaged panels due to improper protection or mishandling is the responsibility of the installer.
AR-L AND AR-C INSTALLATION

RECEIVING AND STORAGE:
The extrusions should be stored in a clean, dry place protected from the weather. They should be stored in the original shipping cartons until they are ready to be assembled and installed in the ceiling. Do not store other materials on top of the cartons. It is suggested that the extrusions be stored at room temperature for twenty-four hours prior to installation.

MOUNTING
All necessary and prudent safety procedures should be followed while handling, preparing and installing the radiant panels.

The preferred mounting suspension on an outside wall is angle molding. If severe irregularities occur in the wall it may be necessary to true up the wall. Do not attempt to bend the angle or panel to conform to the wall. The inside suspension member can be a main runner or any other suspension detail which offers uniform support. If exposed grid is used, standard 15/16” wide main runner is preferred. Pop rivets should not be used on the suspension system for the radiant panel.

The inside and outside suspension members must be parallel. The assembled panel cannot be bent or cut to conform to non-parallel or non-straight suspensions members. The spacing between the suspension members must be large enough to allow for panel installation and expansion during use. (Aluminum expands at the rate of 1-1/2 inches per hundred feet, per 100° F. temperature change). The spacing between the suspension members must be small enough so that the panel cannot fall out of the ceiling even if it is rests tight against either suspension member.

Radiant panels are designed with cross-channels near each end of the panels with an additional two to five cross-channels (based on the length of the panel) spread out over the length of the panel. The channels are used for bracing the panel as well as hanging the panel. All radiant panels must have at least two hanging devices per cross-brace.

INSTALLATION OPTIONS
Within a suspended ceiling: Ensure that the top of the panel is at least 2” from the structure above.

Mounted in visible sections: Panel sections should be separated by 1/2” -1”.

Concealed installation application above perforated panels: Ensure the panel is at least 2” above either the perforated panel or the overhead structure.

PANEL ASSEMBLY REQUIREMENTS
The Airtite AR-M panels are part of the finished surface within the occupied space. The face must be protected at all times from damage. White gloves should be worn by all personnel touching the panel to eliminate fingerprint marks. The gloves should be discarded once they become soiled.

INSTALLATION
The radiant panels should be suspended per local building codes using such items as threaded rod or wire, with additional options of carabineer, etc.

START-UP
Each zone of panels should be pressure-tested for leaks as required in specifications. All system piping should be thoroughly cleaned, flushed, drained and refilled before the radiant panels are connected into the system.

With boiler in operation and circulators on, set control valves to full flow position. Flow in excess of 0.4 GPM per circuit is required to push the air out of the tubing and interconnects on the panel. Gradually bring the system to design temperature. The actual temperature drop through the panel will only be as designed when building is under design load. Balancing should be done for the radiant ceiling system during a cloudy day in the wintertime. After balancing return the control valves to automatic operation.
AR-L AND AR-C MAINTENANCE AND CLEANING

MAINTENANCE

Maintenance is normally limited to cleaning of the panel face as required. Since there are no moving parts nothing else is required.

CLEANING PANEL FACE

*Dirt, scratches, abrasions or stains*

Loose dirt—such as ordinary dust—should be removed from the surface of the panel with a soft brush or vacuum cleaner. The panel may be washed using a mild detergent cleaner applied with a cellulose sponge. The sponge should hold just enough solution to adequately wet the surface. The edge of the sponge can be used to clean out grooves. Rinse the panel with a damp sponge of clean rinse water. The rinse water should be changed frequently to avoid streaking.

**CAUTION**

DO NOT USE AN ABRASIVE CLEANER ON THE PAINTED SURFACE. DO NOT SLOSH EXCESSIVE WATER UP IN THE CEILING, AS IT MAY GO INTO PANEL JOINTS AND CAUSE DISCOLORATION OR LOOSENING OF PAINT FINISH.

Removing small scratches, abrasions, stains, etc. may be accomplished by use of a solvent such as trichloroethylene or trichloroethylene on a soft white cloth. Use caution not to remove the paint. Use only a small amount. Be sure the follow label directions when using these solvents.

PAINTING

Tiny scratches should be feathered in with a fine artist’s brush. Touch up spray paint can be supplied by Steel Ceilings, Inc.

All surfaces should be thoroughly cleaned prior to repainting. It is recommended that a flat oil base paint be used. Metallic finishes should not be applied to the Airtite radiant ceiling because they have a low emissivity and therefore will reduce the radiant performance of the ceiling. The painter should test a sample of the paint in an inconspicuous place to assure compatibility of the new and old surfaces. Electrostatic paint spraying will normally produce the best results.